**Accessory Publication 2**

# Alternative methods for estimating fire radiative power from MODIS observations when fire boundaries are known

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MODIS fire detections were obtained from the MYD14 active fire product (e.g., Giglio et al. 2003) and, of the four coincident MODIS overpass events for RxCADRE 2012 burns (S6, L1G, L2G and L2F), only two (L2G and L2F) were represented in MYD14. MODIS detected two fire pixels for the L2G burn with fire radiative power (FRP) totaling 130.9 MW, and three fire pixels from one complete scan for the L2F burn totaling 151.9 MW (see Table AP2-1, row 1). The S6 burn signal was too small to be detected in the significantly-off-nadir MODIS pixels as can be seen in Fig. AP2-1. Although the MYD14 algorithm detected an elevated signal for the L1G burn, it classified it as cloud due to the significant cloud cover over or near the fire (see Fig. AP2-1). However, in spite of the extensive cloud cover, knowing that the detected signal was indeed from the L1G fire provided the rationale to utilize the available data to retrieve FRP. This was done and a cumulative total FRP of 110.8 MW was found over four pixels for the L1G burn (Table AP2-1, row 1). The extent of attenuation of FRP by cloud cover is unknown.

In an effort to get the most realistic estimates of FRP possible, different methodologies for calculating FRP from the MODIS data were implemented for the fires. For each burn, FRP was calculated in two modes: by summation of the individually retrieved fire detections, and by clustering together all of the MODIS pixels touching the burn blocks prior to FRP retrieval (Table AP2-1, column 'Mode'). In addition to using the MYD14 default background characterizations, the small number of burns in this experiment allowed us the flexibility to manually inspect the background pixels of the MODIS fire detections. This was done to ensure that any non-clear background pixels were properly excluded from the analysis (Table AP2-1, column 'Background'). The fact that the differences between rows 1 and 3 and between 2 and 4 in Table AP2-1 are relatively small corroborates the clustering methodology. These small differences are due to the different order of calculations and the slightly different selection of background pixels. Thus, for L1G that has a high level of cloud contamination in the background, the difference between the pixel and cluster modes using the default background characterization is greater than the others. Having corroborated the clustering technique, more complete FRP values could be obtained by clustering all the pixels containing any portion of the burn plot on the ground (Table AP2-1, column 'Cluster Size').

The official MYD14 product corresponds to the first row of Table AP2-1, although the value for L1G was not available in the product but was calculated in this study based on the MYD14 algorithm. When a manual inspection of the background was done to ensure that none of the selected background pixels were contaminated (by clouds, water, smoke, significant shadows, etc.), the FRP values for L2G and L2F remained in close agreement with the MYD14 product (Table AP2-1, row 2). However, the stricter manual implementation of cloud detections yields a noticeable decrease in FRP for L1G to 94.4 MW. This value is an underestimate of L1G FRP

because, although the background was properly classified, the fire pixels still contain many clouds that lower the fire signal. Because we have confidence in the clustering method (see above), we used this method to calculate FRP for all pixels that overlap the burn blocks (see Fig. AP2-1). The clustering method yields values shown in Table AP2-1, rows 5 and 6, that are significantly higher than the corresponding prior estimates. Note that the cluster analysis was not successful for L1G in this case due to the great variability in brightness temperatures of pixels covering the fire because of the extensive cloud cover in that area. Therefore, the inclusion of non-detected parts of a fire can mitigate satellite underestimation of the whole-fire FRP output. We have the greatest confidence in the FRP estimates that are derived from the cluster method and that manually select background pixels. These FRP estimates are 151.4 MW for L2G and 174.6 MW for L2F. Due to the increased uncertainty in the L1G case from cloud attenuation of the fire signal that prevented FRP estimation using the whole-fire clustering technique, we can state with confidence only that FRP from L1G was greater than 94.9 MW.

**References**

Giglio L, Descloitres J, Justice CO, Kaufman YJ (2003) An enhanced contextual fire detection algorithm for MODIS. *Remote Sensing of Environment* **87**, 273–282. doi: 10.1016/S0034-4257(03)00184-6

**Table AP2-1.** FRP values generated using different methodologies from MODIS data for the L1G, L2G and L2F burns. Each method can be described by its FRP-retrieval "mode", background characterization, and by cluster size (if applicable). Under the 'Mode' column, 'pixels' denote hot spot determination of individual pixels followed by aggregation of their FRP values, whereas 'cluster' denotes pixel aggregation covering the fire followed by a single FRP retrieval for the whole cluster. Under the 'Background' column, 'default' denotes when the default MYD14 characterizations are used to select the background, and 'manual' denotes when the background pixels are manually selected. Under the 'Cluster Size' column, 'default' refers to the use of only pixels flagged as fire in the 'pixels' Mode, and 'all' refers to the use of all pixels that include any portion of the burn block on the ground (see Fig. AP2-1).

| Methods of generating FRP | | | Fire radiative power | | |
|---|---|---|---|---|---|
| Mode | Background | Cluster size | Burn unit | | |
| | | | L1G | L2G | L2F |
| | | | | (MW) | |
| Pixels | Default | – | 110.8 | 130.9 | 151.9 |
| Pixels | Manual | – | 94.4 | 130.1 | 155.6 |
| Cluster | Default | Default | 123.8 | 134.7 | 160.8 |
| Cluster | Manual | Default | 94.9 | 133.7 | 158.5 |
| Cluster | Default | All | 149.6 | 152.6 | 179.1 |
| Cluster | Manual | All | – | 151.4 | 174.6 |

**Fig. AP2-1.** Diagrams of the MODIS 1-km pixels superimposed on MODIS 250-m imagery for units S6, L1G, L2G and L2F. The burn blocks are outlined in yellow, and the MODIS pixels that cover all or a portion of the burn block, keeping in mind the MODIS triangular response function that reaches halfway into the neighboring pixels along-scan, are outlined in red (Table AP2-1, rows 5 and 6). Individual pixels whose signals were strong enough to be deemed as fire detections are shown with a red dot (Table AP2-1, rows 1 and 2). Pixels excluded from the background characterization are "X"ed out: clouds are shown in purple, water is shown in blue, and user-selected contaminated pixels are shown in thick black.